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Technical News Bulletin

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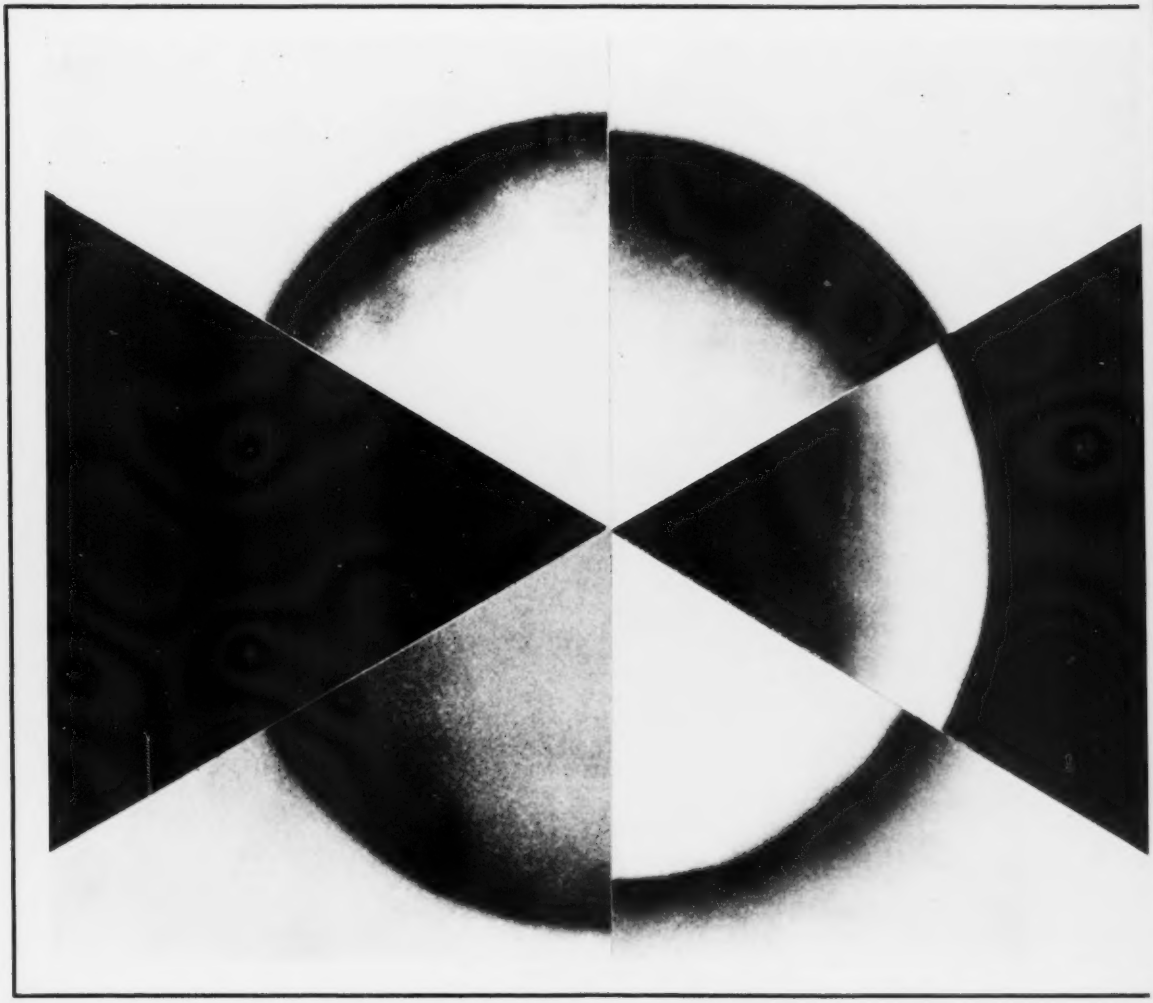

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- The Institute for Basic Standards
- The Institute for Materials Research
- The Institute for Applied Technology

The TECHNICAL NEWS BULLETIN is published to keep science and industry informed regarding the technical programs, accomplishments, and activities of all three institutes.

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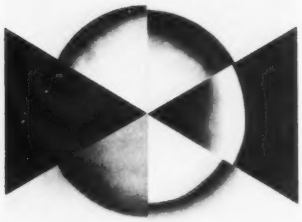

COVER

Composite photomicrograph of a small glass sphere. The composite shows six partial images of the same sphere photographed under different conditions of illumination or focus, and illustrates the NBS findings that diameters of small spheres appear to vary with changes in the measuring procedure.
(*Story on p. 206*)

package checking procedures for AEROSOL PRODUCTS

■ Simple, rapid procedures for checking the delivered weight of aerosol products have been developed at the NBS Institute for Applied Technology. The work was undertaken since many of the States have recently adopted a package regulation specifying that the net content of an aerosol package is the delivered weight. The Chemical Specialties Manufacturers Association (CSMA) and industry cooperated with the Institute's Office of Weights and Measures in developing the testing techniques. As a result, uniform procedures are now available to both aerosol packagers and weights and measures officials for determining the delivered weights of aerosol products.[1]

According to present estimates, a record 1½ billion units of aerosol products are expected to be sold in the United States this year. The rapid growth of the industry, as evidenced by the large volume of current sales, has created problems with respect to quantity control of aerosol packaged products. The present study was therefore undertaken by Stephen Hasko of the NBS staff to solve these problems. The new procedures have been issued as supplements to NBS Handbook 67, *Checking Prepackaged Commodities.*[2]

In the study, the aerosols investigated were divided into four groups. The first embraced foam products such as shaving creams, shampoos, and cosmetics; the second included hair sprays, starches, insecticides, and other low-viscosity products; the third included more viscous products such as varnishes, undercoatings, and lubricants; and the fourth, foods such as frostings, whipped toppings, and the like.

Stephen Hasko of the Institute's Office of Weights and Measures weighs a series of aerosols in preliminary tests.

Several promising methods of test were investigated, including a Canadian method that gave good results but took an excessive amount of time to complete. An accelerated test method was developed at NBS based upon (a) simplicity of test, (b) time requirements, (c) reproducibility of results, and (d) the similarity of test results to those obtained in ideal consumer usage (where expelling instructions are carefully followed).

In this method, the gross weight of an aerosol container is first obtained and recorded. A light-weight portable test stand equipped with an adjustable valve-button depressor is then used to exhaust the container's contents. After the outside of the container is rinsed and dried, it is again weighed to determine its weight plus any product that may have been retained.

Since the procedures evolved from the accelerated test method do not deliver as much product as is obtained under ideal consumer usage, a nominal test allowance is made based upon product type and net weight. This allowance is subtracted from the amount obtained in the second weighing. The difference between the gross weight and the adjusted weight of the container is thus calculated as the product's net weight. On the average, this net weight should at least equal the weight of the contents declared on the container label.

Two related findings of interest were made during the study:

1. Upwards of 10 percent of usable product often remains in discarded aerosol containers. This finding is based on measurements of retained product in hundreds of discarded containers obtained from a cross section of consumers.
2. Such retention is apparently due to (a) lack of observance of labeled instructions, since only nominal retentions were found in most controlled consumer tests (in which instructions were carefully followed), and (b) negligence or indifference of the consumer to expelling all of the product (in many cases, additional product was expelled from the discarded containers).

A major result of this joint study has been the general adoption of an "overfill" concept by aerosol packagers to compensate for product retained when the package checking procedures are followed. The cooperation of industry, CSMA, and NBS is eliminating a thorny issue to the general satisfaction of both the enforcement official and the aerosol packager.

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[1] *For further details, see* Weight checking of aerosols, *by Stephen Hasko, Modern Packaging* **38**, *141 (1965).*

[2] *NBS Handbook 67 is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402 (35 cents). The supplements may be obtained from the Office of Weights and Measures, National Bureau of Standards, Washington, D.C., 20234.*

A brass cup containing a cyanide dye in solid solution is attached to an electron beam apparatus by Mr. McLaughlin.

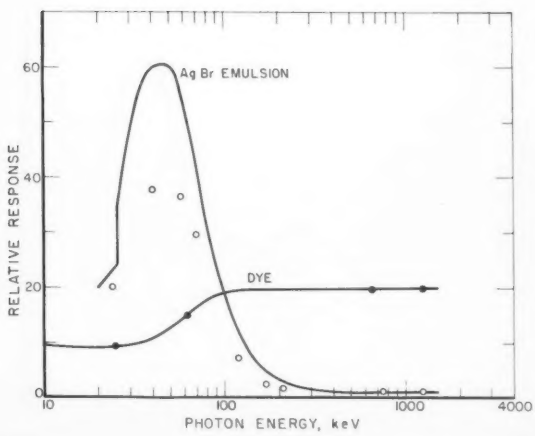
DYE SYSTEMS

for measuring large radiation doses

■ Dye systems capable of detecting high-level radiation in the 10^5 to 10^8 rad range have been studied by William L. McLaughlin of the NBS Institute for Basic Standards.[1, 2] These dyes were previously developed for ultraviolet imaging; [3] they are colorless until exposed to intense radiation, and their many advantages include low cost, low energy dependence, rate independence, stability, and high spatial resolution.

Advances in intense-beam radiation technology and the demands of many related applications have produced a need for better dosimetric techniques. For example, food can now be pasteurized and sterilized for long-term storage without refrigeration by administering large doses of ionizing radiation. The new dye systems are especially suited to the urgent needs of the radiation processing industries for a simple indicator of radiation dose distributions on a microscopic scale and for a quick and low-cost monitor to put on materials or food packages during processing irradiation. Other potential applications include x-ray micrography, mixed-radiation, and molecular biology studies. The dyes will be of particular value in situations where indication of a given radiation effect, on a "go-no go" basis, must be viewed from a distance.

In many high-level radiation applications—especially in food processing—the need for a uniform dose distribution is important. These new systems are capable of high-resolution measurement of gradients—



change of radiation dose over distances of the order of microns—in a heterogeneous radiation field of 10^5 to 10^8 rads.

Conventional dosimeters—such as ionization chambers, silver-halide emulsions, and certain liquid-chemical, glass, and solid-state devices—have been used for dose-distribution measurement, but these systems are generally unsuitable for the monitoring of radiation field gradients on a microscopic scale. With films and glasses which are capable of measuring high-resolution dose distributions, energy dependence of the response may cause difficulties in attaining accurate readings.

In the past, radiation chemical changes in solid materials containing dyes have made for convenient, if not altogether satisfactory, visualization of radiation field gradients. Methylene blue, for example, is one of the most familiar dyes for dosimetry. However as with other oxidation-reduction reactions involving organic dyes, whether in a liquid, gel, or solid medium, inaccuracies are caused by sensitivity to dissolved oxygen and organic impurities.

It has been known for some time that the colorless cyanides of aminotriphenylmethane dyes in alcohol solutions become deeply colored when exposed to ultraviolet of certain wavelengths, but in this state the color is not stable. It was found, however, that in solid solution with certain organic activators, these dyes have a long shelf life before irradiation, become deeply colored when exposed to intense ultraviolet and x-rays, and do not suffer a reverse (dark) reaction. The commercial use of these dyes so far has been for ultraviolet imaging; they are insensitive to visible and infrared radiations.[3]

Intense colors are formed when the electron, x-, or gamma-ray irradiation reaches the megarad or megaroentgen level, the color depending on the type of dye used. Some of the characteristics of the dye cyanide systems are listed in table 1, and potential applications are found in table 2.

NBS is now in the process of constructing new radiation facilities at its Gaithersburg (Maryland) site.

TABLE 1. *Characteristics of the dye cyanide systems exposed to ionizing radiation*

Sensitive to wavelengths less than 0.33 micron
Sensitive to beta rays, neutrons, protons, etc.
Response linear from 0.1 to 10 Mrad
High molecular yields (G-values $\sim 10^2 - 10^3$ molecules/100 eV)
No rate dependence
Approximate water-plastic-soft tissue equivalent
Small variation in response with temperature change
Relatively insensitive to oxygen and impurity effects
Sensitizer and dye forms are stable
Same response in air and in vacuum
High output signal-to-noise ratio
Can be incorporated in a number of media of various sizes and shapes

TABLE 2. *Potential applications for ionizing radiation measurement by the dye cyanide systems*

Radiation dose distribution studies
Beam mapping in radiological phantoms
Interface distributions (microscopic)
Food and materials processing
High-intensity beam monitoring
X-ray micrography and autoradiography
Differentiation of mixed radiations
X rays-ultraviolet light
X rays-electrons
Gamma rays-neutrons
Gamma rays-heavy particles
Studies of radiation effects due to low-energy events in molecular biology

New equipment will include an intense beam linear accelerator [4] and a high flux research reactor.[5] Further tests on these dye systems and other potential dosimeters for solving high-level dose measurement problems are planned when these facilities are completed.

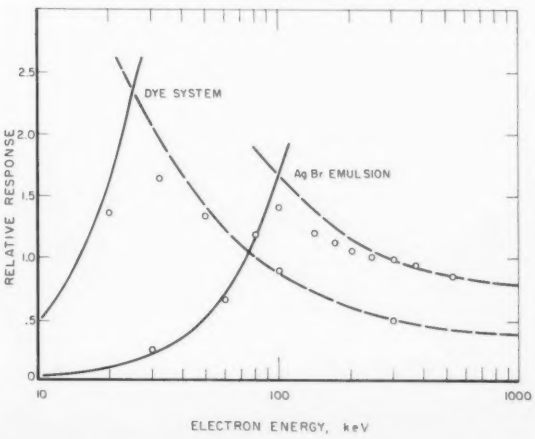
[1] *For further technical details, see* Low-atomic number dye systems for ionizing radiation measurement, *by W. L. McLaughlin and L. Chalkley, Phot. Sci. Eng.* **9**, *3 (1965).*

[2] Microscopic visualization of dose distributions, *W. L. McLaughlin, Intern. J. Appl. Radiation Isotopes, in press.*

[3] Photometric papers sensitive only to short wave ultraviolet, *by L. Chalkley, J. Opt. Soc. Amer.* **42**, *387 (1952).*

[4] Linac (High-intensity electron accelerator for new NBS site), *NBS Tech. News Bull.* **44**, 5 (1960).

[5] High flux research reactor for new NBS site, *NBS Tech. News Bull.* **45**, *8 (1961).*



Left: *Comparison of the spectral sensitivity of a typical dye cyanide system and that of a silver bromide emulsion used for x and γ rays. The points (● for dye system, ○ for AgBr emulsion) are experimental data; the curves represent ratios of mass energy absorption coefficients, dye system/air and AgBr emulsion/air.* Center: *William McLaughlin uses a recording microdensitometer to observe the transmission characteristics of a cyanide dye that has been exposed to intense-beam radiation.* Right: *Spectral sensitivities of the dye system and the AgBr emulsion, for plane-perpendicular electron beams. The points are experimental data; the solid curves represent the computed electron range and the broken curves show calculated electron energy loss.*

Rare Earth Ionization Energies Calculated

■ The experimental determination of the ionization energies of the singly ionized rare earths (lanthanides) is not expected in the near future, because of the great complexity of the energy level structures involved. For this reason, Jack Sugar and Joseph Reader of the NBS Institute for Basic Standards have performed a semiempirical calculation to determine these energies.[1]

The ionization energies of fourteen of the fifteen singly ionized rare earths (which are actually the second ionization potentials of the neutral atom) were calculated, and the new values may be put to a wide variety of uses by scientists. For example, the compilation of thermodynamic data such as heat of vaporization (an important quantity to the builders of space vehicles) relies on accurate values of ionization potentials. Some of the rare earths are used as control rods in atomic reactors, and others have a host of diversified uses in commercial and industrial applications. Any data that provide more information about these highly useful metals will be valued additions to the National Standard Reference Data System recently established at NBS.[2]

The basis of the calculation is the regular behavior of the relative properties of the 6*s* and 7*s* electron orbits throughout the lanthanide period. Evidence for this regular behavior has been presented previously in a paper in which the limit of the $4f^3ns$ series of praseodymium III was calculated.[3] In the present study the same arguments were applied to the singly ionized species.

TABLE 1. *Quantities involved in the determination of the ionization energies. The term value* T *refers to the position of the first members of the specified series.*

Atom	Series	T	Lowest parent position	Ionization energy
		cm^{-1}	cm^{-1}	*eV*
La II...	4fns.....	82 140	105+14 148	11.06
Ce II...	$4f^2$ns.....	83 480	210+ 3 854	10.85
Pr II...	$4f^3$ns.....	84 810	315	10.55
Nd II...	$4f^4$ns.....	86 090	420	10.73
Pm II...	$4f^5$ns.....	87 400	525	10.90
Sm II...	$4f^6$ns.....	88 740	518	11.07
Eu II...	$4f^7$ns.....	89 990	735	11.25
Gd II...	$4f^75d$ns.....	97 400	535	12.1
Tb II...	$4f^9$ns.....	92 360	525	11.52
Dy II...	$4f^{10}$ns.....	93 650	473	11.67
Ho II...	$4f^{11}$ns.....	94 780	315	11.80
Er II...	$4f^{12}$ns.....	96 030	210	11.93
Tm II...	$4f^{13}$ns.....	97 120	105	12.05
Yb II...	$4f^{14}$ns.....	98 150	0	12.17
Lu II...	$4f^{14}5d$ns....	106 480	825+11 796	13.9
	$4f^{14}6s$nd....	95 520	14 181	

The calculation was made in two parts, using the equation

$$I_p = T + \delta$$

where I_p is the ionization potential being calculated, T is the term difference between the first parent level and the series limit, and δ is the distance from the ground state to the first parent level. The quantity δ was calculated using a known formula and T was found using the Rydberg-Ritz formula.

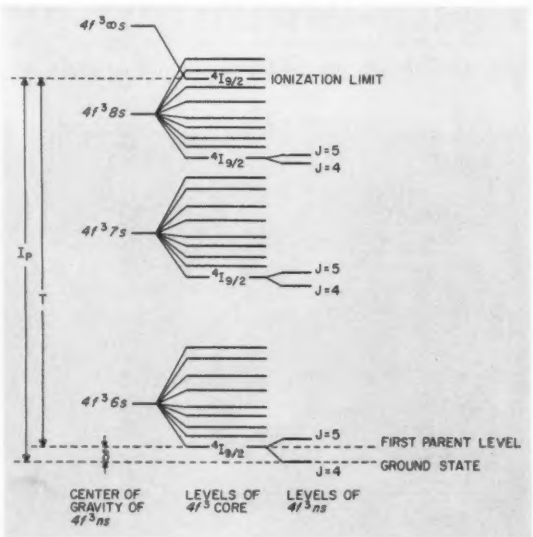
The results for the ionization energies are given in the last column of table 1. A value of 8065.7 cm^{-1}/eV was used as the conversion factor. The estimated uncertainty in these calculations is ±0.08 eV except for the cases of gadolinium II and lutetium II where the uncertainty was estimated to be ±0.4 eV.

[1] *For further technical details, see* Ionization energies of the singly ionized rare earths. *Jack Sugar and Joseph Reader, J. Opt. Soc. Am.* **55,** *(1965).*

[2] National Standard Reference Data System—plan of operation, *by Edward L. Brady and Merrill B. Wallenstein, NSRDS–NBS–I (1964) (available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402).*

[3] Nuclear magnetic moment of Pr^{141} from the hyperfine structure of doubly ionized praseodymium, *by J. Reader and J. Sugar, Phys. Rev.* **137,** *B784 (1965).*

Schematic representation of the $4f^3ns$ levels of praseodymium II. The levels shown do not correspond to the real energy level positions, but are intended to illustrate the procedure used here. δ was calculated from known equations and T was formed using the Rydberg-Ritz formula.



NBS *Sets Up Metrology Lab in Latin America*

■ The Bureau recently designed and established a metrology training center for Latin American countries, as part of the U.S. State Department's Agency for International Development program. Located at the National University, Bogotá, Colombia, the new laboratory has been equipped with length, mass, and volume standards calibrated at NBS. Weights and measures field standards similar to those used in this country have also been installed.

The facilities have thus far been used to train members of the University's physics department faculty who will conduct future training courses. Colombian, Ecuadorian, and Venezuelan government officials and inspectors also attended the training course, which was conducted by H. F. Wollin and T. M. Stabler of the NBS Office of Weights and Measures.

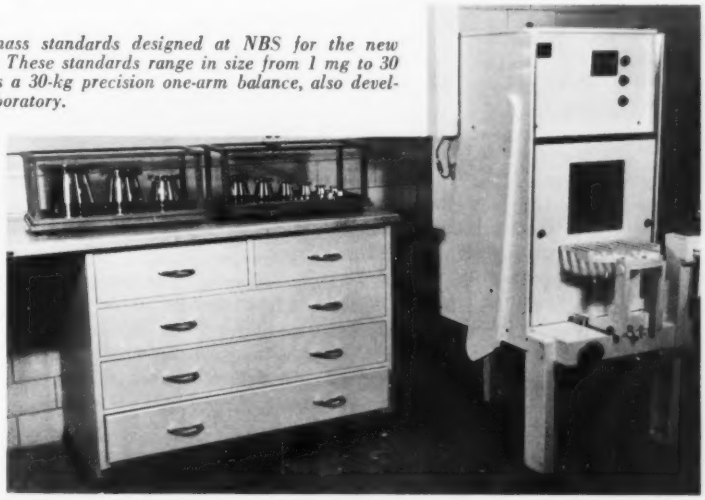
NBS publications, translated into Spanish, were used as training manuals. These publications contain United States specifications, tolerances, and regulations for commercial weighing and measuring devices. In addition to laboratory training, field inspections were made. Procedures were demonstrated for checking prepackaged commodities in markets and gasoline retail meters in automobile service stations. Inspections were also conducted of warehouse equipment for weighing large truck loads and of the measuring apparatus in fuel oil bulk plants.

Standards Installed

The primary length standard installed in the new laboratory is a stainless steel combination yard and meter bar graduated in units of both the English and metric systems, since both systems are used in Latin America. The laboratory working standard is a standard length "bench" mounted on wall brackets. This bench is actually a stainless steel bar graduated in units along its length to 16 feet and to five meters. A chrome-plated steel tape, 100 feet long, and graduated in metric units up to 30 meters, is also part of the laboratory equipment.

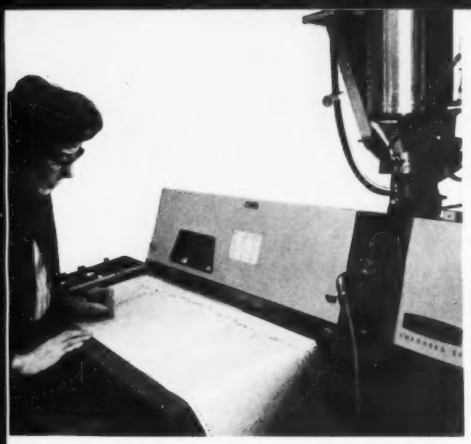
The primary mass standards, of a new type designed at NBS, consist of 30 stainless steel units ranging in size from 1 mg to 30 kg. Also installed in the laboratory are two stainless steel 250-kg weights that may be used singly or together in weight calibrations; a massive balance having a 1200-kg capacity; and smaller balances of 30-, 6-, and 1-kg capacities, respectively.

The volume standards to be used in the laboratory for liquid measurements consist of a series of pipets and burets. The pipets have capacities ranging from 100 ml to 5 liters, and the burets have 1-ml and 1/10-ml graduations, respectively.



On the left, mass standards designed at NBS for the new metrology lab. These standards range in size from 1 mg to 30 kg. At right is a 30-kg precision one-arm balance, also developed for the laboratory.

New Free Radical Observed



Marilyn E. Jacox examines the infrared spectrum of a free radical. Liquid hydrogen or liquid helium in the Dewar (upper right) is used to freeze the free radicals in inert gas matrices. They are then examined through a window in the cryostat (out of view directly under the Dewar) by an infrared spectrophotometer.

■ A new free radical, ClCO, has been generated by Marilyn E. Jacox and Dolphus E. Milligan of the NBS Institute for Basic Standards.[1] ClCO is an intermediate in the reaction of chlorine to form phosgene, but despite numerous studies of the reaction, no direct observation of this free radical has ever before been reported.

Free radicals—chemical species that possess one or more unpaired electrons—are of considerable importance to scientists conducting studies of the chemistry of the upper atmosphere and of combustion phenomena. They are also of importance in such varied applications as air pollution control and high-energy rocket propellants.

Because of the widespread interest in free radicals, NBS undertook in 1952 a three-year program of basic research in order to increase fundamental knowledge of the formation, properties, and storage of these highly reactive molecular fragments.[2] Since then, interest in this field has continued and scientists at NBS have pursued a varied program of free radical research.

When a free radical is generated, its characteristics must be determined, and this is most often accomplished through infrared and ultraviolet absorption studies.[3] However, most free radicals are highly unstable, and this has hindered investigations. Several methods of stabilization have been devised; the most promising is the matrix isolation technique which "freezes" the material and thus permits experimental observation. In this technique, the source of free radicals is mixed with a dilutent (which does not absorb infrared radiation) and the mixture is deposited on the cold (4–20 °K) window of a cryostat. Ultraviolet irradiation is then used to photolyse (chemically decompose by irradiation) the frozen mixture and concentrate the free radicals. The infrared spectrum of the free radicals can then be recorded.

The most satisfactory sources of Cl atoms for this work was found to be HCl with noncondensable gases removed by freezing at 77 °K. Other sources of Cl atoms used were Cl_2, Cl_2CO, and $(ClCO)_2$. The matrix gases (dilutents) used were argon and C.P. grade carbon monoxide.

The base of the cryostat used in these experiments[4] could be rotated to permit vacuum ultraviolet photolysis of the sample with a beam directed perpendicular to the face of the cold window. The samples were condensed on a cesium iodide window through a jet directed at an angle of approximately 45° with respect to the window axis. It was possible to conduct simultaneous deposition and photolysis either with an external radiation source directed through the observation window of the cryostat or with the vacuum ultraviolet photolysis lamp. All observations were made at 14 °K.

Infrared spectra were recorded on a double-beam, prism-grating spectrometer. Under the conditions of a typical experiment, the resolution and frequency accuracy are both approximately 1 cm^{-1} in the spectral range 400-3000 cm^{-1}. Table 1 gives the thermodynamic properties of ClCO as determined by this work. The three vibrational fundamentals are located at 281, 570, and 1880 cm^{-1}.

The reaction was found to take place with virtually zero activation energy, thus providing direct experimental verification of an earlier deduction based on kinetic analysis.

TABLE 1. *Thermodynamic properties* (cal*/mole- °K) of ClCO

T (° K)	C_p°	$\frac{H^\circ - H_0^\circ}{T}$	$\frac{-(F^\circ - H_0^\circ)}{T}$	S°
273.16	10.61	9.14	53.42	62.55
298.16	10.78	9.27	54.22	63.49
300	10.79	9.28	54.28	63.55
400	11.31	9.72	57.01	66.73
500	11.70	10.08	59.22	69.30
600	12.03	10.38	61.08	71.46
700	12.31	10.64	62.70	73.30
800	12.55	10.86	64.14	75.00
900	12.74	11.06	65.43	76.48
1000	12.91	11.24	66.60	77.83
1100	13.05	11.40	67.68	79.08
1200	13.16	11.54	68.67	80.21
1300	13.25	11.67	69.61	81.27
1400	13.33	11.78	70.47	82.25
1500	13.39	11.89	71.29	83.18
2000	13.60	12.29	74.77	87.06
3000	13.77	12.76	79.83	92.59

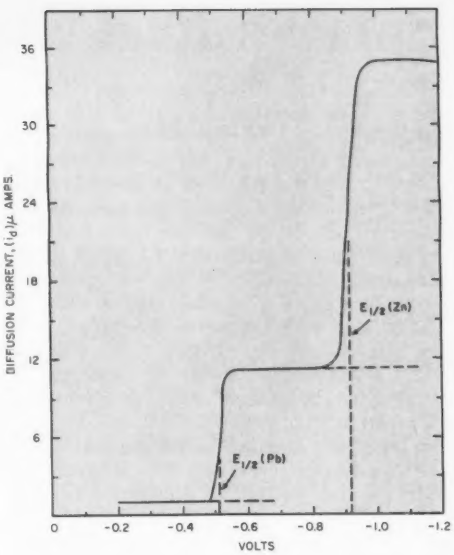
*1 calorie = 4.185 joules

[1] *For further technical details, see* Matrix isolation study of the reaction of Cl atoms with CO. The infrared spectrum of the free radical ClCO, *by Marilyn E. Jacox and Dolphus E. Milligan, J. Chem. Phys. (in press).*

[2] Results of free radical research, *NBS Tech. News Bull.* **44,** *100 (June 1960).*

[3] Infrared studies of free radicals, *NBS Tech. News Bull.* **48,** *128 (August 1960).*

[4] Infrared spectroscopic study of the photolysis of methyl azide and methyl-d_3 azide in solid argon and carbon dioxide, *by Dolphus E. Milligan, J. Chem. Phys.* **35,** *1491 (1961).*



Simultaneous polarographic analysis of Pb(II) and Zn(II) in a 4M acetic acid-ammonium acetate supporting electrolyte shows plateaus for each ion species. The ion concentration is determined as a function of the difference of plateau height in terms of diffusion current.

Improved method speeds analysis of *PAINT PIGMENTS*

■ Scientists at the NBS Institute for Applied Technology have recently used polarographic methods to determine the concentrations of white lead, zinc oxide, and titanium dioxide in paint pigments. As part of a general program to introduce improved techniques in the analysis and testing of organic coatings, H. W. Berger and B. C. Cadoff investigated [1, 2] the possibility of replacing "wet chemical" methods of analyzing paint pigments with polarographic methods.

The results of their investigation show that polarographic methods represent a substantial saving in time and effort over the classical wet chemical procedures currently used by industrial and government laboratories. The precision and accuracy of the polarographic methods are within the limits generally set for chemical analysis of paint pigments. In addition, when one of the components accounts for 10 percent or less of the total pigment, these methods have considerable advantage over chemical procedures which require larger samples to assure accurate results.

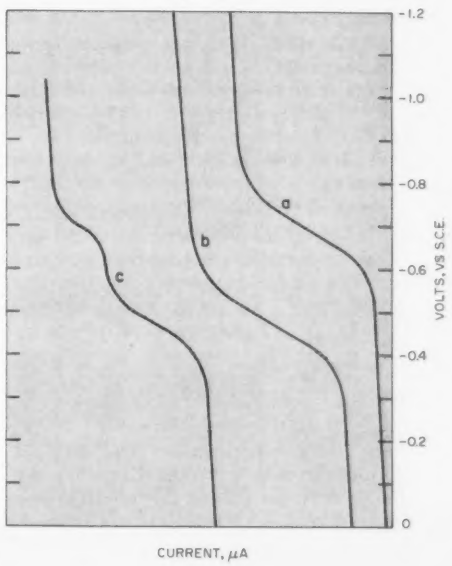
An example of the time and effort saved by the polarographic methods is the analysis of a common white exterior house paint. This paint, formulated according to Federal Specification TT–P–102a, contains a pigment composed of white lead, zinc oxide, and titanium dioxide. Analysis of this paint by the chemical method requires three sample digestions, five filtrations, two titrations, a drying to constant weight, and a reduction on a Jones Reductor. Polarographic analysis, however, requires only two sample digestions and two quantitative transfers.

Polarographic analysis is based on the fact that the electric current formed between two electrodes is directly proportional to the concentration of ions in the electrolyte. The ions are reduced at a dropping mercury electrode in an "H" type electrolysis cell. A polarograph connected to the mercury electrode and to a removable saturated calomel electrode records the current as the ions are reduced. When ion reduction reaches a maximum the polarograph records a current "plateau." The value of this plateau current for an unknown ion concentration is compared to that for a known ion concentration in the same supporting electrolyte.

For polarographic analysis of Pb(II) and Zn(II), acetic acid-ammonium acetate buffer was the supporting electrolyte. Standard solutions of known lead and zinc concentration were prepared to calibrate the system, using lead and zinc obtained from NBS melting point standards (NBS Nos. 49d and 43d). The relative standard deviations for Pb(II) and Zn(II) were 0.21 and 0.61 respectively, for simultaneous determinations.

One synthetic and five commercial pigments were analyzed for Pb(II) and Zn(II) by polarographic and wet chemical methods (Federal Standards No. 141,

(*Continued on p. 211*)



Characteristic curves show the effect of sulfate ion concentration on diffusion current in polarographic analyses of Ti(IV) when an excess of sulfate causes a wave to appear at –0.7 V (curve c) which is attributed to a Ti-sulfate complex (curve a) formed at the expense of the Ti-EDTA complex (curve b).

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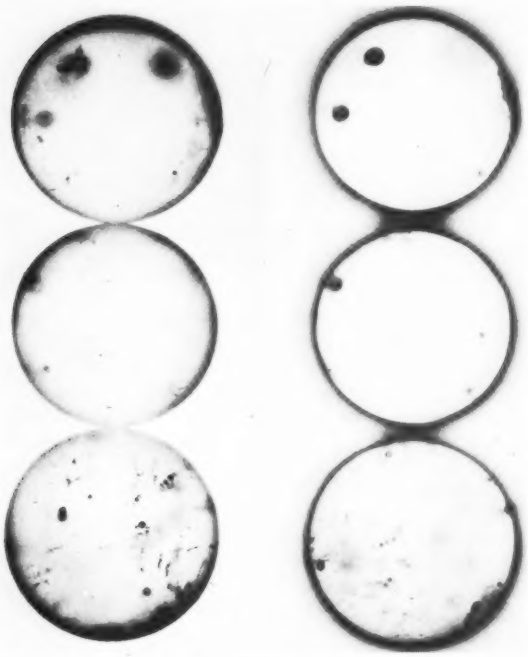
Measurement of Small Spheres Evaluated



These photomicrographs apparently show two groups of microscopic spheres; those on the left appear to be touching each other while those on the right do not appear to be in contact. Actually both photomicrographs were made of the same group of spheres, but at different focuses. The spheres in the group on the right are in contact, but because of incorrect focusing they appear smaller than they are; measurement of the diameters of these spheres will therefore be in error.

■ Accurate measurement of the diameter of microscopic spheres is important in a number of areas. For example, the spreading property of paint and the settling time of cement depend upon constituent particle size, and the effectiveness of many chemical catalysts in suspension depends on the size of the spherical catalyst particles. Also, in the treatment of some blood diseases, the sizes of the red and white corpuscles must be accurately known.

A recent study by Charles P. Saylor of the NBS Institute for Materials Research has shown that errors of 40 percent or greater often occur when the diameters of small spheres are measured by conventional microscopical techniques.[1] The main source of error was found to lie in the production of a falsely focused image of the sphere associated with the wide angle of illumination required for such microscopic measurements. The study showed that alternative techniques can be used to avoid this source of error.

Previously many experimenters had thought that any uncertainties in measuring the diameters of microscopic spheres must be due to the physical optics of the measuring system and thus would not be susceptible to experimental analysis.* Early in the present investigation, however, it became apparent that the geometry of the system was a significant factor in the production of error. First of all, the error was found to increase with sphere size; moreover, it was too large to be due entirely to limitations on resolving power.

Initial investigation indicated that inaccuracies were influenced by differences between the index of refraction of the mounting medium and that of the spheres and also by the focal position, aperture, and resolution of the measuring microscope. To study one source of error at a time, large spheres were used so that the limit of resolving power would not affect the relative error. It was determined that use of larger spheres would not alter the geometrical optics of the measurement if all other factors were kept the same.

In making the diameter measurements with large spheres the root of the problem soon became apparent. It was found that an "edge," either real or apparent, was observed whenever illuminating light struck a sphere tangentially. If the light is parallel to the axis of observation, it strikes the sphere tangentially at its equator and thus produces an edge that is a true image of the sphere at its circumference. However, light traveling oblique to the axis of observation strikes the sphere tangentially at points other than the equator, and if the microscope is focused on a plane through these points, an "imaginary edge," smaller than the true circumference, is seen. Attempts to rid the field of view of imaginary edges by illuminating the spheres only from the direction of observation are necessarily unsuccessful because light from a variety of angles is necessary in the formation of all optical images.

In the course of the work, four alternative techniques for measuring sphere diameters were used and found to give results in close agreement. One method involves pushing the spheres with a micromanipulator until they are in contact and then making a chain measurement. Another uses diaphragms which block out all of the light to and from a portion of the sphere except that which strikes along selected directions. A third method utilizes mounting media with indices of refraction nearly equal to that of the spheres, and the fourth measures the ring of dust particles and imperfections on the sphere surface.

The error involved in measurements by these techniques will naturally depend upon many variables, including the size of the spheres measured and the skill of the experimenter. However, in the NBS study, the error associated with these alternative methods was found to be less than 5 percent, whereas the conventional techniques introduced error of from 10 to 40 percent in measuring spheres of 2 to 10-μ diameter.

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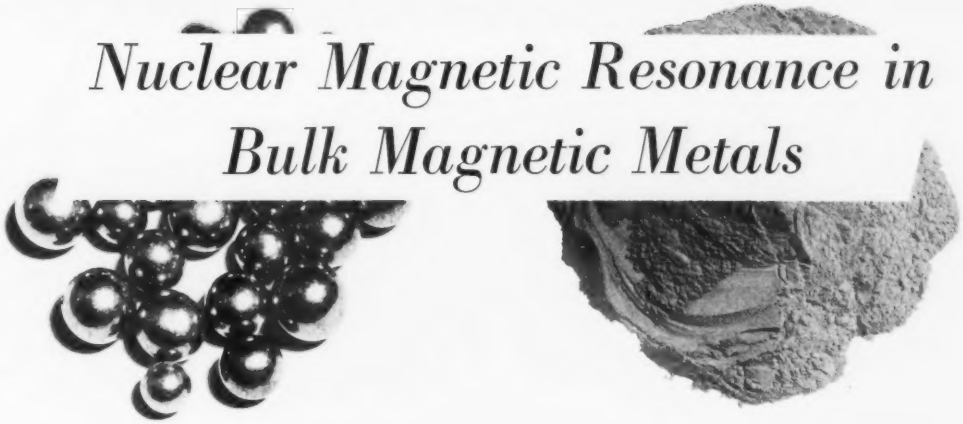
[1] *For further technical details, see* A study of errors in the measurement of microscopic spheres, *by Charles Proffer Saylor, Appl. Optics,* **4**, 4 (1965).

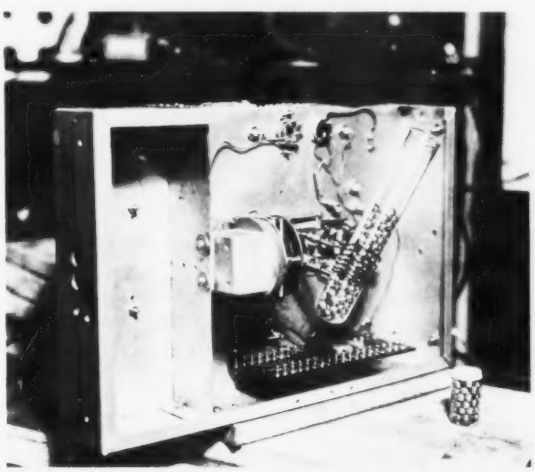
**This uncertainty was observed in published work by Dana Bishop of NBS in 1934. However, his observation was not accepted by other scientists because it did not seem reasonable to them.*

Nuclear Magnetic Resonance in Bulk Magnetic Metals



■ A study by Lawrence H. Bennett of the NBS Institute for Materials Research has shown that the nuclear magnetic resonance (NMR) signal in a bulk nickel sample is extremely intense, comparable to those obtained in fine powders.[1] The shape and strength of the signal indicate an increased enhancement factor in bulk ferromagnetic metal. This finding is in contrast to those for nonmagnetic bulk metal samples where weak signals can be expected. It shows that bulk specimens may be used for NMR studies of magnetic materials, with consequent savings in time and expense.

In a nuclear magnetic resonance experiment, a radio wave is applied to a specimen. At the appropriate frequency, a resonance absorption of radio power is obtained. As in spectroscopy, this resonance appears as a line, and the measurement of the characteristics (width, position, shape, etc.) of this line yields such information as the crystal and electron structure of the nucleus under study.

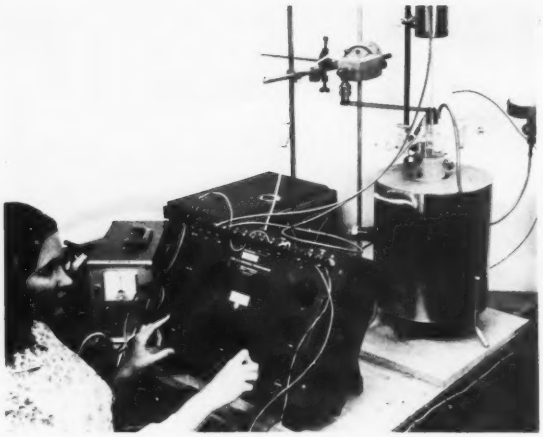


NMR is now being used with nonmetals in a variety of studies. It is a nondestructive process and is highly efficient in determining structure and monitoring chemical reactions. However, since radio waves do not penetrate very deeply into metals, most nuclear magnetic resonance experiments in metals are performed on finely divided specimens such as powders. But making fine powders is a time-consuming and expensive procedure, usually involving the preparation of the bulk material first, and this has tended to discourage the study of NMR in metals. The results of the present work, however, indicate that it may be more attractive than had been previously thought for scientists to undertake direct bulk metal NMR studies and to investigate possible industrial applications such as those now being used with nonmetals. In addition, there is theoretical interest in relating the observed signal enhancement to the magnetic properties of the metal.

In the NBS experiments, a marginal oscillator [2] was used to observe the NMR absorption of Ni^{61} in both pure Ni powder and Ni pellets. Both the powdered sample and the pellets (radius about 0.36 cm) occupied cylindrical volumes of about 3-cm diameter and 4-cm height. Resonance could not be observed in the Ni pellets as received, probably because of strains in the metal. However, a strong resonance was observed after annealing in vacuum for one hour at 200 °C. Virtually the same intensity was observed after annealing for one hour at temperatures up to 1000 °C, but no resonance could be observed in a sample annealed for one hour in air at 500 °C, probably because of surface oxidation.

(*Continued on p. 209*)

Top: *High purity nickel in bulk and powdered form.* Left: *Nuclear magnetic resonance studies are carried out on high purity nickel pellets in a test tube surrounded by an NMR coil.*



Susan Meador adjusts the circuit null balance to obtain a reading of the emf of a molten salt concentration cell, contained in a furnace (right).

Molten Salt Concentration Determinations

Equations developed for glass membrane electrodes

■ Technological applications for molten salts have greatly increased in recent years. Extractive metallurgy uses molten-salt electrolytic processes extensively for the commercial production of aluminum, magnesium, tantalum, lithium, and sodium. Electrorefining metals in molten salts produces the high-purity metals needed for the formation of superior alloys. Molten salts, which are inexpensive and generally have high heat capacity, are also potentially useful in nuclear reaction applications, especially as fuels or coolants.

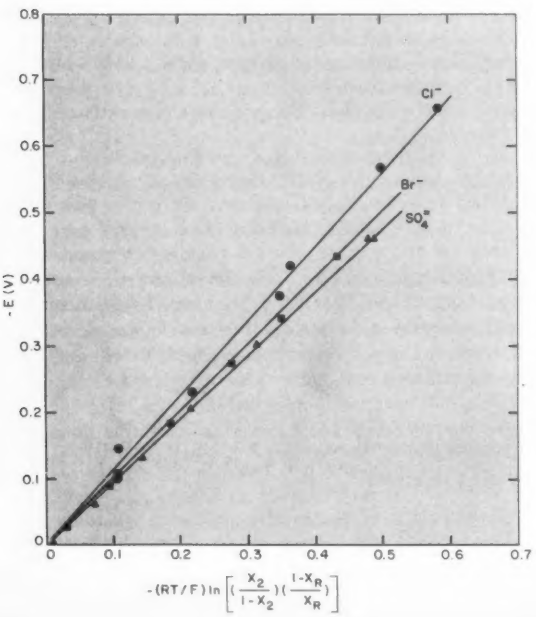
Accurate measurement of molten-salt concentrations, important for these and other applications, can be made electrochemically by means of concentration cells. In these cells, a glass reference electrode (glass tube closed at one end) is used, the most common electrode of this type being the liquid-junction (reference) electrode in which the solution inside the electrode and the melt outside are in direct contact through the glass wall by means of a pinhole, asbestos fiber, or capillary tube.

A disadvantage of this type of electrode is that it introduces a liquid-junction potential of unknown magnitude which must be considered unless the concentration of the melt solution surrounding the electrode is nearly the same as that of the solution inside. It is also difficult to prevent the melt and electrode solutions from mixing after a period of time.

Recently Kurt H. Stern and Susan E. Meador of the NBS Institute for Basic Standards completed a study which shows that good results for a range of melt concentrations can be obtained using a glass membrane (reference) electrode—a glass tube closed at one end but having no aperture in the wall—in place of the liquid-junction electrode.[1] Use of the glass membrane electrode avoids the difficulties inherent in the liquid junction. An additional advantage is that this electrode can be made easily and inexpensively in the laboratory as needed.

In the NBS investigation, glass membrane electrodes were used in silver ion [2, 3] concentration cells. The concentrations of the melt and of the electrode solution—a mixture of silver halide and sodium halide—were known. Cell emf was measured between two silver wires. One wire was immersed in the melt, the other in the solution in the glass membrane electrode.

Cell emf and its dependence on melt concentration were used to determine the form of the Nernst equation which quantitatively relates cell emf and melt composition. An interesting result of this determination was that for cells with glass membrane electrodes, the ion



Emf shown as a function of melt concentration (X_2), in a concentration cell with a glass membrane reference electrode. From the graph, silver ion concentration in a silver-sodium ion concentration cell with chloride, bromide, or sulfate anions can be determined by means of a potentiometer measurement of cell emf.

Glass membrane electrode used in molten salt concentration cells. Cell emf, from which the concentration of the melt can be determined, is measured between the wire inside the electrode and one placed directly in the melt. A ceramic tube is used around the wire inside the electrode to prevent excessive bending of the wire which becomes pliable at high temperatures.

transport numbers used in the equation are characteristic of the glass and are independent of the melt composition.[4]

Based on the Nernst equation and the experimental data, a graph was plotted showing cell emf as a function of melt concentration. The use of this graph made it possible for unknown concentrations of molten salt melt solutions to be determined simply from a measurement of cell emf. For example, in silver-sodium ion concentration cells with variously, chloride, bromide, and sulfate anions, silver cation concentrations as low as 1 part in 10^5 were determined with an accuracy of one percent by means of a potentiometer measurement which was related to the graph.

At present the method as described is practicable only for molten salt mixtures containing over 5 mole percent of sodium ions on both sides of the membrane; for such mixtures the Nernst equation is simplified because the sodium ions will then carry nearly all the current through the glass membrane.

A glass membrane electrode containing a silver halide-sodium halide mixture and a silver wire should also perform satisfactorily in measuring any other metal ion concentrations in any other melts, as long as a wire of the ion to be measured is placed in the melt. In this case, however, since the system is no longer a simple concentration-cell the Nernst equation would require consideration of additional parameters. Special precautions may also be necessary to prevent corrosion of the electrodes. These and other aspects of the problem are currently being investigated.

[1] Electrode potentials in fused systems X. Glass membrane electrodes for molten salts, *by K. H. Stern and Susan E. Meador, J. Res. NBS* **69A** *(Phys. and Chem.), No. 6 (Nov.–Dec. 1965).*

[2] Electrode potentials in fused systems VI. Membrane potentials, *by K. H. Stern, J. Phys. Chem.* **67,** *893 (1963).*

[3] Electrode potentials in fused systems VII. Effect of ion size on membrane potentials, *by K. H. Stern and J. L. Stiff, J. Electrochem. Soc.* **111,** *893 (1964).*

[4] Electrical conductivity of glass immersed in molten salts, *by K. H. Stern, J. Electrochem. Soc.* **112,** *208 (1965).*

Nuclear Magnetic Resonance–*Con.*

The NMR in the pellets and in the powder showed comparable signal-to-noise ratios, and the NMR line widths were also about equal. The line shape indicated a mixture of absorption and dispersion in the powder and pure dispersion in the pellets. It has previously been shown [2] that when low rf levels are applied to the Ni powder, the line shape indicates a mixture of absorption and dispersion, whereas at high rf levels the line shape shows an almost pure dispersion signal in the powder. However, even at the low applied rf levels, the pellets displayed a pure dispersion signal. Thus, the effective rf level was higher in the pellets, indicating the presence of a correspondingly higher enhancement factor.

The large enhancement of the rf level in the pellets leads to an increase in the signal intensity. From a comparison of the observed signal intensities, neglecting changes in penetration depth and surface roughness, the enhancement factor was estimated to be about 30 times larger in the pellets than in the powder.

While the feasibility of bulk-metal NMR studies has been demonstrated, it is not clear as to whether similar studies with bulk alloys can be carried out, since impurity pinning of the domain walls (via dislocation) may be the limiting factor in determining the enhancement. Also, an increase in enhancement factor cannot necessarily be expected in all ferromagnetic metals because in some cases the maximum enhancement already appears to be obtained in the powder. These questions are now under investigation.

[1] *For further technical details, see* Nuclear magnetic resonance in bulk metal samples, *by Lawrence H. Bennett, Phil. Mag. In press.*

[2] Line shapes, saturation behavior, and temperature studies in the nuclear resonance of nickel, *by R. L. Streever and L. H. Bennett, Phys. Rev.* **131,** *2000 (1963).*

New technique may

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Close-up view of the apparatus used to obtain ultrapure materials. One impurity in the substance is a red dye (gray in photo). Two silver strips (one in front and one in back) are seen close to the growing mound. Note that the color of the substance is lighter above than below the mound and that the mound itself shows almost no trace of the dye.

■ Charles Proffer Saylor of the NBS Institute for Materials Research has devised and experimentally tested a technique that may open the door to regions of ultrapurity never before attainable. First presented before the September, 1965, meeting of the American Chemical Society, the technique has many of the desirable features of conventional purification procedures but is designed to avoid the disadvantages associated with each. In tests of the new method, a single stage of purification reduces the amount of impurity present to less than one-one thousandth of the starting concentration and takes only about one-half hour. A three stage model that has undergone preliminary tests reduces the amount of impurity much further. A seven stage unit that is being constructed will have provision for the automatic introduction of starting material, the removal of concentrated impurities and collection of the highly purified end product.

This work was done as part of the Institute's program of research to develop standard reference materials for calibration of analytical instruments and procedures. Recent improvement in analytical methods has given rise to a need for reference materials of ultrahigh purity, and the Bureau is engaged is continuous research to provide improved standards for this purpose.

There is widespread belief that as the impurity in a substance is reduced the difficulty of further impurity removal increases to the extent that absolute purity can never be obtained. However, Dr. Saylor believes that his technique provides for additional stages of purification which will permit the same proportional impurity reduction as the initial stage. In a theoretical paper recently given before a meeting of the Twentieth Congress of the International Union of Pure and Applied Chemistry (IUPAC) in Moscow, he expressed the belief that absolutely pure materials can be obtained—that it is only the inability of scientists to measure ultrapurity and the lack of a technique which avoids recontamination during operation that hinder attainment of a perfect end product.

The apparatus used in the NBS technique consists of a hollow ring (toroid) which rotates slowly about its axis. The material to be purified fills about one-half of the inner volume of the ring and is melted using an external heater. Strips of silver sheet (which remain stationary with respect to the rotating ring) are placed around the bottom half of the ring at equal intervals. The lower temperature of the strips causes material close to them to freeze on the inner surface of the ring, forming a solid mound of crystalline substance.

As the ring moves, the front edge of the mound (which has grown in a cold region) starts to melt as it approaches a warmer region. Growth continues on the rear edge of the mound as long as it remains under the influence of the cooling strip. The melted material from the front edge flows over the mound and some of it refreezes on the rear edge. Because of the growth configuration (i.e., the coupling together of particles as they grow on each other), molecules of the substance

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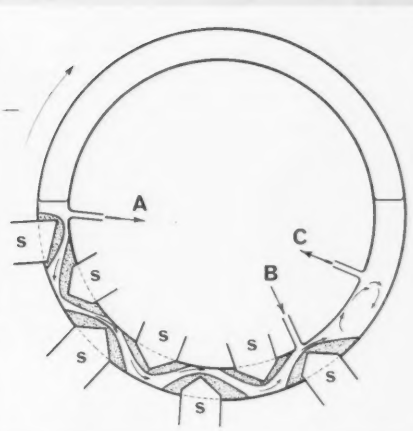
duces impurity
by a factor of at least 1000



Schematic of the ultrapurification apparatus. The substance to be purified grows in mounds on the inner surface of the rotating ring in the areas cooled by the silver strips (S). As a solid mound leaves a cold region and enters a warm region, some melting will take place. The melted substance will grow preferentially on the rear (colder) surface of the mound. The impurities flow downward as the mounds move upward. Concentrated impurities are removed at C. The purified substance can be put through any number of stages and then collected at A. Starting material can be introduced at B; this point must be closer to C than to A.

being purified tend to grow on the rear surface in preference to any impurity molecules that might be present.

Such preferential growth is the basis of most purification by freezing (or melting) procedures including the popular zone melting technique, but this new procedure provides for collection of the purified material, transportation of concentrated impurity away from the growth area and its removal from the system, and for the introduction of new starting material during operation. These features are not found in the other techniques.

As molecules of the substance being purified grow preferentially on the rear edge of a mound, some material will be melting from the front edge. Therefore, a particular molecule will actually move through the mound, its position changing as new molecules grow behind it and molecules in front of it are melted off; the speed with which it moves through the mound will be determined by the speed of the rotating ring.

The impurities flow along the canal-like passage between the mounds until they reach a point (*C* on schematic) where provision has been made to withdraw them. After repeated freezing and melting the purified substance can be removed at *A*. New material can be introduced at point *B* during operation, usually in an amount equal to that of the concentrated impurity which is removed. Removal of impurity, thus assuring no recontamination, is a particularly important part of the process. In other techniques impurities are concentrated and trapped in pockets within the growing crystal, thus prohibiting absolute purity unless the pockets are removed by other means.

Under favorable conditions and proper control, the mole fraction of impurity can be reduced by at least a factor of 10^3, and quite possibly 10^4, in one stage of operation. This strong rejection factor is achieved because the mounds are never allowed to melt completely. As they melt on one edge, growth takes place on the other edge, and the result is a continually improving crystalline purity. According to Dr. Saylor, this impurity reduction will be the same for succeeding stages. Thus, even highly impure materials may be used to produce absolutely perfect crystals in short periods of time. For example, if a mole of material is assumed to have 0.1 percent impurity, there should be approximately 6×10^{20} molecules of impurity present (there are 6.23×10^{23} molecules in a mole). If the impurity is reduced by a factor of only 10^3 per stage, at the end of six stages the impurity should be only 600 molecules per mole, and after seven stages the chances are almost 2 to 1 that not a single impurity molecule will be present. Putting the material through additional stages would further reduce (by a factor of 10^3 per stage) the possibility that even one impurity molecule remains.

PEAK-PULSE POWER CALIBRATIONS INITIATED

■ The Radio Standards Laboratory at Boulder, Colo., has inaugurated a new service for the calibration of coaxial rf peak-pulse power meters. This service is available for a frequency band of 950 to 1200 MHz and a peak-power range of 1 mW to 3 kW. Calibrations are performed at pulse widths of 2 to 10 microseconds and repetition rates of 100 to 1600 pps, with a maximum duty cycle of 0.0033 due to generator limitations.

According to manufacturer's specifications the uncertainty in measurement associated with some pulse power meters can be as high as 10 or 15 percent. This condition can result in inadequately designed equipment not meeting contract specifications or in costly overdesign.

Requests for peak-pulse power measurements had come in from industrial laboratories and government agencies, and about a year ago the work of developing an appropriate facility was begun by the High Frequency Calibration Services Section. The new facility, recently completed, is expected to alleviate the unfulfilled calibration need.

The calibration system makes use of a sampling-comparison method. (See block diagram.) This method, developed by Hudson, et al.[1] employs a specially constructed diode switch to extract a sample of power from an rf pulse for measurement. The switch is also used to obtain a similar sample from a cw signal whose power can be accurately measured. By adjusting the cw level to obtain similar readings for the pulse and cw samples on a level monitor, the peak-pulse power can be determined.

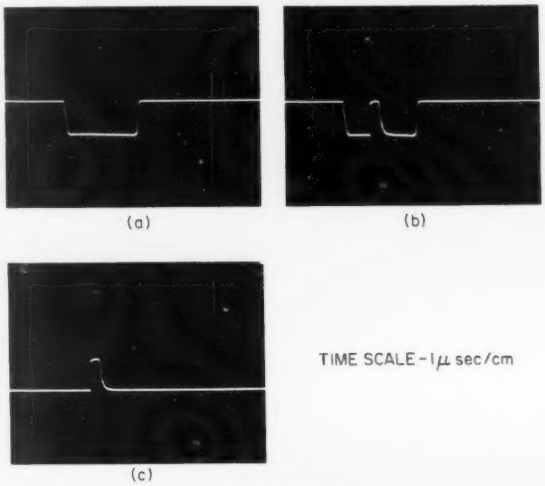
The calibration console was designed to facilitate taking of data by a single operator. All controls used in making a measurement are convenient to him on a sloping-front panel. An oscilloscope, used to view the pulse and the notch (caused by the extraction of a sample from the pulse) is in front of the operator, as is the sample power level monitor and the digital readout of the cw power. A complete set of measurements at any one frequency can be made by one person from a single location.

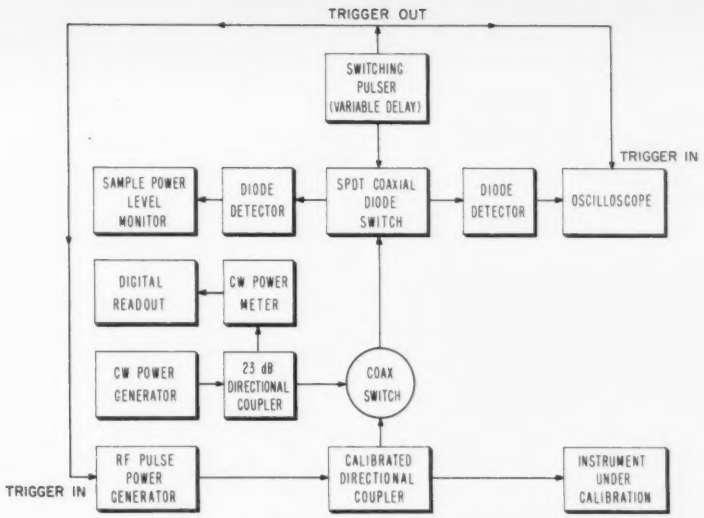
The pulse and cw power generators, along with their associated equipment, are contained in two adjoining racks. This auxiliary equipment includes frequency determining devices, in-line power meters for checking generator level, and a calibrated power meter for measuring the cw power. This equipment needs to be handled only during the initial setup and when changing frequency.

While the range of the basic system is limited to 0.1 to 1.2 W by the power handling capability of the diode switch, higher or lower powers can be measured by means of calibrated directional couplers. These couplers are connected to cables and housed in a recessed compartment adjacent to a large work area. They, plus the cable used to bring the pulsed rf signal to the

Top: *General view of rf peak-pulse power calibration console. Racks at left hold the power generators; sloping racks in center contain equipment and controls for making measurements. Instrument being calibrated is at right.*

Typical waveforms observed on oscilloscope when connected to normally closed arm of the coaxial diode switch. (a) Envelope of unsampled rf pulse. (b) Envelope of sampled rf pulse. (c) Envelope of sampled cw signal.





Block diagram of sampling comparison method used in making rf peak-pulse power calibrations. Equal samples of pulsed rf power and cw power are intercompared and the peak pulse power computed by an accurate measurement of the cw signal.

diode switch, are located so that they may be extended and connected to the instrument under test. A special fitting on the Type N connectors clamps the cable to eliminate any instability caused by cable flexing. The proper coupler is selected by merely moving a manual coaxial switch.

The performance of the calibration console was checked by comparing it against the peak-pulse power standard maintained by the High Frequency Electrical Standards Section. Since the calibration of the directional couplers is a possible additional source of error, intercomparisons of the two systems were first made over the power range of 0.1 to 1.2 W without these couplers, then at higher power levels with the couplers. The results show no significant difference between the two standards and both, therefore, have the same degree of uncertainty, ±3 percent. This is based on an estimate of 2 percent for the basic system which includes the measurement of the cw power, and an additional 1 percent for the calibration of the directional couplers.

It is planned to expand this calibration service to include additional frequency bands and higher power levels. Also, new type diode switches, which promise to give improved accuracy to the basic system, are under development at the Radio Standards Laboratory. It is hoped the uncertainty of measurement can be reduced to 1 percent or better.

[1] Measurement of rf peak-pulse power by a sampling-comparison method, *by P. A. Hudson, W. L. Ecklund, and R. A. Ondrejka, IRE Trans. on Instrumentation, Vol.* **I–11,** *Nos. 3 and 4, December 1962.*

Paint Pigments–*Continued*

Methods 7041 and 7091). The comparison between assays gave average differences for Pb(II) and Zn(II), respectively, of 0.10 and 0.15 percent.

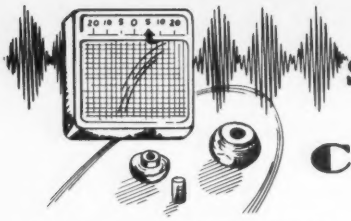
The polarographic method for the analysis of Ti(IV) is based on the reduction of a Ti(IV)-ethylenediaminetetraacetic acid (EDTA) complex. TiO_2 is prepared for analysis by dissolving it in sulfuric acid and ammonium sulfate, followed by dilution, buffering with sodium acetate-acetic acid ($pH=4.7$), and complexing with EDTA.

The effects of high concentrations of sulfate ion were investigated to determine the conditions under which sulfate competition with EDTA for Ti(IV) is minimized. The concentration of sulfate ions under which no significant competition occurs is 0.4 M.

Solutions containing Ti(IV) over a concentration range of 3×10^{-5} to 8×10^{-3}M were analyzed with an overall relative standard deviation of 0.5 percent. The results of the polarographic method and Federal Standard No. 141 (wet chemical) Method 7081 were compared for NBS standard TiO_2, one synthetic pigment, and five commercial pigments. The average difference in assays of TiO_2 was 0.10 percent.

[1] The Polarographic analyses of white lead and zinc oxide in white paint pigments, *by H. W. Berger and B. C. Cadoff. Official Digest* **37,** *No. 480, 28–34 (January 1965).*

[2] Polarographic analysis of titanium (IV)–EDTA complex; applications to paint pigments, *H. W. Berger and B. C. Cadoff, J. Res. NBS* **69C** (Engr. and Instr.) *No. 1, 67–70 (Jan.–Mar. 1965). Also in Official Digest* **37,** *No. 480, 35 (Jan. 1965).*



STANDARDS AND CALIBRATION

Changes in NBS Radio Broadcasts

Adjustment of Time Pulses

In accordance with the Bureau's policy of giving monthly notices regarding changes in phases of time pulses, notice is hereby given that there will be an adjustment in the phase of seconds pulses emitted from radio station WWVB, Fort Collins, Colo. On December 1, 1965, the clock at the station was retarded by 200 ms at 0000 hours UT (7 p.m., EST, of November 30). The successive time pulses emitted from station WWVB are one second apart. The carrier frequency of WWVB is 60 kHz, and is broadcast without offset.

Notice is also hereby given that there was no change in the phases of time pulses emitted from radio stations WWV, Greenbelt, Md., and WWVH, Maui, Hawaii, on December 1, 1965. These pulses at present occur at intervals which are longer than one second by 150 parts in 10^{10}, due to the offset maintained in carrier frequencies, as coordinated by the Bureau International de l'Heure (BIH).

The phase adjustments ensure that the emitted pulses from all stations will remain within about 100 ms of the UT2 scale. They are made necessary because of changes in the speed of rotation of the earth with which the UT2 scale is associated. Daily UT2 information is obtained from forecasts of UT2 provided weekly by the U.S. Naval Observatory in accordance with the close cooperation maintained between the two agencies.

Frequency Offset for 1966

The carrier frequencies of broadcasts by National Bureau of Standards radio stations WWV in Greenbelt, Md., WWVH in Maui, Hawaii, and WWVL in Fort Collins, Colo., will be offset during 1966 by -300 parts in 10^{10} from their nominal values. These nominal values are taken with respect to the United States Frequency Standard (USFS). The adjustments in carrier frequencies will be made at 0000 UT on January 1, 1966.

The new offset value was announced on September 21, 1965 by the Bureau International de l'Heure (BIH), after an evaluation of predictions of the trend in the UT2 scale. The fractional offset is twice the value -150×10^{-10} used in 1964 and 1965. In accordance with the announcement, changes will be made in the carrier frequencies of all broadcasts which follow the coordinated universal time (UTC) system.

The standard carrier frequency of broadcasts by radio station WWVB in Fort Collins, Colo., will not be changed. It is not offset from its nominal value of 60 kHz, taken with respect to the USFS.

As a result of the new offset, the intervals between timing pulses for the UTC system will differ in length from a second by a greater amount than in 1964 and 1965. The intervals will be longer than a second by 300 parts in 10^{10}. By contrast, the time intervals between pulses broadcast from WWVB will continue to be one second in length as referred to the standard atomic time scale, NBS–A, based on the USFS and in accordance with the definition of the unit of time agreed upon internationally.

Metrologia, Vol. I, No. 3

Articles in the latest issue of this new journal deal with four major areas of scientific metrology: temperature standards, interferometric determination of length, the acceleration of gravity, and time and frequency standards.

A paper by C. R. Barber and A. Horsford (National Physical Laboratory, Teddington, England), "Differences between the thermodynamic scale and the International Practical Scale of Temperature (IPST) from 0 °C to −183 °C," presents data of the sort needed to pave the way for an extension of the IPST to temperatures below −183 °C (about 90 °K). Of interest to those engaged in precise length measurement is the article "An air refractometer for interference length metrology," by J. Terrien (BIPM, Sèvres, France). This article describes the construction, method of use, and performance of a device for measuring the refractive index of the ambient air.

By far the longest paper is "The absolute determination of the acceleration due to gravity," by A. H. Cook (NPL, Teddington, England). This paper begins with a consideration of the place of measurements of g in the system of fundamental constant of physics and celestial mechanics and the history of gravity measurements down to around 1950. It then launches into a critical review of theory, recent measurements, and present status of the subject.

"Cesium beam atomic time and frequency standards," by R. E. Beehler, R. C. Mockler, and J. M. Richardson (NBS, Boulder, Colo.) discusses the metrologically significant characteristics of devices that generate radiation whose frequency has been temporarily designated by the International Committee of Weights and Measures as a basis for the physical measurement of time and frequency. From results of a fairly large number of comparisons of cesium standards one with another, it is concluded that frequency differences are within $\pm2\times10^{-10}$ for all standards and $\pm1\times10^{-10}$ for laboratory-type standards.

For further information on standards and calibrations, see Peak Pulse Power Initiated *on p. 210, and* WWV to Be Relocated *on p. 215.*

WWV to be Relocated

■ A target date of zero hours, July 1, 1966, has been set as the time for the first broadcast by the NBS high-frequency (short wave) radio station WWV from its new transmitters to be located at Fort Collins, Colo. WWV, at its present site at Greenbelt, Md., will go off the air at 0000 hours, July 1, 1966, and WWV, Fort Collins, Colo., will come on the air in its place simultaneously. The station, which is operated by the NBS Radio Standards Laboratory, broadcasts on a continuous basis, night and day, except for a silent period of four minutes each hour.

The Radio Standards Laboratory, a part of the NBS Institute for Basic Standards, establishes and disseminates the Nation's standards of electromagnetic measurement, including frequency and time.

The move is the culmination of a long-planned consolidation of NBS broadcast facilities which is designed to improve these services. It will result in a more efficient transmitter station and improved WWV reception for most of the country. A small group of users within about 25 miles radius of the Greenbelt location, who have been receiving WWV signals with very high accuracy because of their proximity to the station, may find the signal slightly degraded over the longer path. This problem is under study by RSL to determine whether a special auxiliary service is needed and can be provided.

WWV is the Bureau's oldest standard radio station. Together with short wave station WWVH, Maui, Hawaii, and two stations already located at Fort Collins (WWVB, low frequency and WWVL, very low frequency), WWV is one source of essential broadcast services provided by NBS to U.S. industry, the military services, the National Aeronautics and Space Administration, private and university research laboratories, and thousands of other private and governmental users.

In 1964, Congress appropriated $970,000 to cover the costs of the move from Greenbelt, including the moving of some equipment, purchase of new equipment to replace obsolete items, and new construction required at Fort Collins.

In June 1965, a $297,000 contract was awarded to Technical Materiel Corporation for the eight transmitters for the new station. Four of the high-power, high-frequency transmitters are designed at 20,000 W, and four medium-power, high-frequency transmitters at 5,000 W. One of each of these categories will be a standby transmitter, so that the station will actually have six transmitters in operation at any one time. Operating at half the maximum power rating, the main transmitters will broadcast at 5, 10, and 15 megahertz at 10 kW; and supplementary transmitters will broadcast at 2.5, 20, and 25 megahertz at 2.5 kW.

In September 1965, a $7,024 contract for two monopole antennas and 88-foot steel towers for support was awarded to Collins Radio Company. These two general-purpose antennas will be effective over the entire frequency range (2.5 MHz to 25 MHz). They will permit the station to operate with only slightly reduced efficiency when any of the six special-purpose antennas or regular transmitters are out of order or are being serviced.

Also in September 1965, a $7,075 contract was negotiated with the Rhon Manufacturing Co., Peoria, Ill., for the remaining six steel antenna towers, designed by the antenna section of the Central Radio Propagation Laboratory. They will range from 20 feet to 200 feet in height, and will be vertical, modified sleeve type, ½ wave, dipoles. They will vary in height inversely as the frequency of the broadcast. For the 2.5 MHz broadcast, the 200-foot-high tower will be used; at 5 MHz, a 100-foot-high tower; at 10 MHz, a 50-foot-high tower; at 15 MHz, 33 feet; at 20 MHz, 25 feet; and at 25 MHz, a 20-foot-high tower. All antenna towers will be so positioned that there will be very little "shadowing" from other antennas. This provision in the layout design makes it possible to achieve nearly omnidirectional broadcasting.

All antennas will be fed by coaxial lines to achieve maximum reliability, ease of matching without special networks, and for greater protection from wind and ice. Power to be furnished by the Poudre Valley REA is being brought into the Fort Collins site by underground lines. Construction of the underground lines began in August 1965. Power will be fed from the Waverly substation from the northwest and from the Nunn substation to the northeast of the site. An emergency or stand-by cable will also be provided for the first time.

The transmitter building, also being specified by the RSL staff, is yet to be designed. The building will contain the eight transmitters as well as administrative space for the WWV staff of approximately twelve people who will come to Fort Collins as part of the move.

Established in Washington, D.C., in 1923 as the first U.S. standard frequency station, WWV has grown from a 1 kW station on selected frequencies in the range 125 kHz to 7600 kHz (serving only a score or so of users and offering, at first, only standard frequency broadcasts) to today's 10- and 1-kW broadcasts on six standard frequencies, offering eight distinct services to a vast listening audience. It probably has more listeners than any other station in the world today.

In 1937 other services were added to the frequency broadcasts: standard musical pitch at 440 hertz (A above middle C); seconds pulses (based on Naval Observatory Time); standard time intervals (based on

(*Continued on p. 218*)

PUBLICATION and CONFERENCE *Briefs*

NOTE: Publications noted in this column, unless otherwise stated, may be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402 and local Department of Commerce Field Offices. Technical Note 262, $1.00; Technical Note 262A, $0.50.

Accuracy in Measurements and Calibrations, 1965

Technical Note 262, edited by W. A. Wildhack, R. C. Powell, and H. L. Mason, contains a comprehensive picture of the degree of accuracy in measurement now existing in the United States for many of the physical quantities of importance to science and industry. The information is conveyed through charts which plot the limits of uncertainty of a given quantity ranging from pico units to giga units. Brief discussions prepared by various NBS scientists cover the six basic quantities of the International System and derived quantities in the fields of electricity, metrology, mechanics, thermal, radiation, and radio. Some charts show present estimates of precisions or accuracies for NBS standards available as calibration services to science and industry; others indicate values sought as near-term goals. In some cases an area designated "Non-NBS State of the Art" is given on the chart to indicate how commercial and other government laboratories are progressing in the field of measurement.

This publication should be of interest to a wide range of scientific, technical, and management personnel who are concerned with the accuracy of physical measurements. The machinist will find the answer to how accurate gage blocks can be. An electrical engineer can check the accuracy of his waveguide against NBS uncertainties with the charts provided. The research head for an aerospace industry will be able to see if projected accuracies will keep pace with his research program and if not, will find the name of the person responsible for improving measurement capability to meet these needs.

As an aid to those primarily interested in electrical and radio measurements, a section of this publication is being issued separately as Technical Note 262A, *Accuracy in Electrical and Radio Measurements and Calibrations, 1965*. This Technical Note contains those charts that cover the calibration services from d-c into the microwave region, available at the NBS Boulder Laboratories.

1966 Conference on Precision Electromagnetic Measurements

The 1966 Conference on Precision Electromagnetic Measurements, the fifth in the biennial series, will be held June 21, 22, and 23 at the Boulder (Colo.) Laboratories of the Bureau. The Conference is sponsored by the NBS Institute for Basic Standards, the Group on Instrumentation and Measurement of the Institute of Electrical and Electronics Engineers, and the U.S. Commission 1 of the International Scientific Radio Union (URSI). The Bureau of Continuation Education of the University of Colorado will handle local arrangements.

The aim of the Conference is the advancement of electromagnetic measurement, throughout the coherent frequency spectrum, at levels of precision and accuracy appropriate to the national standards laboratories of the world. Its scope ranges from measurement studies in the traditional fields of low frequency, high frequency, and microwaves to physical studies which may have application to future precision measurements or which may require new measurements standards. Traditionally, the program also includes survey articles presented by leading men in the field.

Chairman of the 1966 Conference is Dr. John T. Henderson, of the Canadian National Research Council. Dr. Kiyo Tomiyasu of the General Electric Company is chairman of the Technical Program, and James Brockman, of the NBS Radio Standards Laboratory, is executive secretary.

The 1964 Conference was attended by more than 600 scientists and engineers, including participants from six foreign countries. It is expected that attendance at the 1966 Conference will be at least as high.

Questions concerning the Conference should be addressed to Mr. John Cronland, Bureau of Continuation Education, 328 University Memorial Center, University of Colorado, Boulder, Colo., 80304.

Thermophysics Specialist Conference

Wide discrepancies between the actual temperature of U.S. unmanned spacecraft and their predicted temperatures were reported at a recent Thermophysics Specialist Conference of the American Institute of Aeronautics and Astronautics. Cosponsored by the Bureau, the National Aeronautics and Space Administration (NASA), and the U.S. Air Force, the Conference was held September 13–15, 1965, at Monterey, Calif., to discuss spacecraft thermal problems and possible means for solving them.[1]

Highlight of the conference was a panel discussion on problem areas revealed by temperature data tele-

metered to earth from test flights, such as the one to Venus by *Mariner II* and the one to Mars by *Mariner IV*. In the first case the vehicle temperature was above and in the second case it was below the predicted temperature at the time of planet "fly-by."

Efforts had been made to correlate the telemetered data with the degradation effects of the space environment on the surface coatings of the vehicles. These coatings had been designed to maintain solar absorptance-surface emittance ratios that would control vehicle temperatures. Instead, temperature control was not achieved in the Venus flight, possibly because the coating was darkened by ultraviolet and particle radiation. In the Mars flight, numerous effects may have caused deviation from the predicted temperature, including radiation, decreasing solar intensity, and the sun orientation of the vehicle at the time of fly-by.

In the discussion it was brought out that launch conditions may darken surface coatings, thus increasing solar absorptance with a resulting rise in vehicle temperature. The example given was the S–IV component of several *Saturn* vehicles that carried *Pegasus* satellites into orbit. The S–IV component was intended to control the temperature of the electronics canister on board. In these flights, however, an active louver control system in the S–IV surface had to be used to keep the canister temperature within tolerable limits. Deposits from the solid propellant retro-rockets of the Saturn S–I component had probably darkened the S–IV surface coating, with further darkening induced by ultraviolet radiation.

In one session of the Conference, J. Crosby and M. Perlow of North American Aviation, Inc., reported on the laboratory testing of a composite coating which was subjected to electromagnetic and particle radiation, shock, vibration, simulated aerodynamic heating, and a 589 °K temperature in vacuum for 8000 hours. Flight data later indicated that the coating had withstood a combination of environmental influences with good results.

In another session, D. Lewis and T. Thostensen of the Jet Propulsion Laboratory and B. D. Pearson of the NASA Ames Research Laboratory described experimental thermal sensors that had been designed to measure the behavior of surface coatings in space. The sensors had been exposed to solar winds and radiations that are not present in earth orbits because the earth's magnetic field has a shielding effect. Telemetered data from the sensors showed that during several weeks of exposure surface coating temperatures rose to higher levels than had been predicted for them.

Additional sessions of the conference dealt with ablation processes during vehicle re-entry of the earth's atmosphere and with the radiation properties of solid materials. Thermal modeling and interface effects and lunar and planetary environments were also discussed.

The Conference proceedings pointed up the need for improved testing facilities that would more realistically simulate the actual conditions of outer space.

[1] *The proceedings of the Conference are to be published by the American Institute of Aeronautics and Astronautics, Inc., 1290 Sixth Ave., New York, N.Y., 10019.*

Computer Program for Thermocouple Tables

■ A program for the production of thermocouple tables for cryogenic use has been developed by R. L. Powell and L. L. Sparks of the Cryogenic Properties of Solids Section at the Boulder (Colo.) laboratories of the Bureau. The tables are usable from liquid helium temperatures at 4 °K to approximately room temperature.

After an individual user makes a spot check of his own thermocouple with its junctions at known temperatures, a computer program is used to compare the results of the spot calibration with an NBS calibration table. The computer then calculates a correction factor and generates a "working" table tailored to the particular thermocouple. The table may be obtained in °C or °K, with any reference temperature within range of the table. Tables can be generated for most of the commercial, low-temperature, thermocouple materials.

This program is compatible with many types of computers, making possible the use of local computers. The NBS Cryogenic Data Center will furnish, at cost, the materials and instructions necessary for the user to develop his own tables. The materials needed are (1) a thermocouple data deck, color coded to agree with ISA's recommended color code for positive thermocouple extension wire, and (2) a program deck, written in FORTRAN II, IV, or 3600, which was developed to adjust the "standard" data to fit a particular thermocouple.

It is preferred that the customer use a local computer. If, however, one is not available the Cryogenic Data Center will process the spot calibration data furnished by the user.

The tables in use at this time contain interim values pending completion of a long-range experimental program to establish industry-wide national standard tables. A few of the national standard tables were available in the autumn of 1965, and all tables will be ready by the spring of 1966.

Norman Ramsey, Noted Physicist, Appointed to Visiting Committee

■ Secretary of Commerce John T. Connor recently announced the appointment of Dr. Norman F. Ramsey to be a member of the Statutory Visiting Committee of the Bureau. Dr. Ramsey is an atomic physicist of note, and a professor of physics at Harvard University.

The Statutory Visiting Committee was set up by the act of Congress which established the National Bureau of Standards in 1901. The act requires the Secretary of Commerce to appoint five eminent scientists to study the technical program and facilities of the Bureau each year and to advise him on the efficiency of the Bureau's operations and the condition of its equipment.

These scientists serve for a term of 5 years. Other present members of the Committee are: Dr. E. R. Piore, Vice President, Research and Engineering, International Business Machines Corporation, Chairman; Dr. Frederick Seitz, President, National Academy of Sciences; Dr. Elmer W. Engstrom, President, Radio Corporation of America; and Dr. Paul C. Cross, President, Mellon Institute.

The new appointee has made important contributions to an unusually large number of scientific fields, ranging from molecular properties to elementary particles.

Of special interest to the National Bureau of Standards is Dr. Ramsey's invention and development of the hydrogen maser, which holds promise of becoming the most accurate time standard yet devised.

Dr. Ramsey has been a trustee of the Carnegie Endowment for Peace since 1960. During the same period, he has also been a member of the Atomic Energy Commission general advisory committee. In 1960, he received the E. O. Lawrence award and medal, given by the Commission for "outstanding contributions to the development, use, and control of atomic energy . . ." In 1947, Dr. Ramsey was given the Presidential Award of Merit for radar development work.

Dr. Ramsey has served in a science advisory capacity to numerous organizations and officials, including NATO, U.S. Department of Defense, the Air Force, and the Secretary of War; and as a consultant to the Office of Scientific Research and Development, and the National Defense Research Committee.

He has been a trustee of Brookhaven National Laboratory since 1952; he headed its physics department in 1946 and 1947. Prior to these dates he was a group leader at Los Alamos, 1943–45. Dr. Ramsey was director of Harvard's nuclear laboratory from 1948 to 1950, and again in 1952.

Dr. Ramsey holds the A.B. and Ph. D. (physics) degrees from Columbia University. He also earned M.A. and D.Sc degrees from Cambridge University, and was awarded an honorary M.A. by Harvard in 1947. He has held several fellowships: the Tyndall (Columbia), the Kellett (Cambridge), a Guggenheim, and one in the department of terresterial magnetism at Carnegie Institution.

Prior to joining the Harvard faculty in 1947, Dr. Ramsey had taught at Columbia University and the University of Illinois.

Dr. Ramsey is a fellow of the American Academy of Arts and Sciences and the American Physical Society. He is a member of the American Philosophical Association, National Academy of Sciences, American Mathematics Society, New York National Academy of Sciences, Sigma Xi, and Phi Beta Kappa.

WWV to be Relocated–*Continued*

what today would be considered a very crude oscillator with an accuracy of only 2 parts in 10^7, as compared to today's accuracy of one part in 10^{11}); and ionosphere bulletins (radio propagation disturbances).

In 1950, 600 Hz modulation was added (used by power companies to regulate their 60 Hz current), as were time announcements in voice each five minutes.

In July 1957, geophysical alerts were added, and in October 1957, the reference for the broadcast carrier frequencies was changed from a Naval Observatory specification to the atomic frequency standard established and maintained at the Boulder Laboratories.

Today, WWV continues to provide services at six standard radio frequencies, including standard audio frequencies (at 1000, 600, and 440 Hz), musical pitch, time intervals (1 second, 1 minute, 1 hour, etc.), time signals (Universal Time), time (UT2) corrections, time code, radio propagation forecasts, and geophysical alerts. No reduction is expected in these services when the station is moved to Fort Collins.

Publications of the National Bureau of Standards

Periodicals

Technical News Bulletin, Volume **49**, No. 11, November 1965. 15 cents.
Annual subscription: $1.50, 75 cents additional for foreign mailing.
Available on a 1-, 2-, or 3-year subscription basis.

Journal of Research of the National Bureau of Standards
Section A. Physics and Chemistry. Issued six times a year. Annual subscription: Domestic, $5.00; foreign, $6.00. Single copy, 75 cents.*
Section B. Mathematics and Mathematical Physics. Issued quarterly. Annual subscription: Domestic, $2.25; foreign, $2.75. Single copy, 75 cents.
Section C. Engineering and Instrumentation. Issued quarterly. Annual subscription: Domestic, $2.75; foreign, $3.00. Single copy, 75 cents.*

*These prices are effective with the January 1966 issues.

Current Issues of the Journal of Research

J. Res. NBS **69B** (*Math. and Math. Phys.*), *No. 4* (*Oct.–Dec. 1965*).
Table of Dedekind sums. R. D. Shipp.
Lattice points in a sphere. M. Bleicher and M. I. Knopp.
Error analysis of phase-integral methods. I. General theory for simple turning points. F. W. J. Olver.
Error analysis of phase-integral methods. II. Application to wave-penetration problems. F. W. J. Olver.
A random walk model of chain polymer adsorption at a surface. II. Correlation between neighboring steps. R. J. Rubin.
Groups of unimodular circulants. R. H. Austing.
A generalization of a result of Newman on multipliers of difference sets. R. L. McFarland.
The bridge tournament problem and calibration designs for comparing pairs of objects. R. C. Bose and J. M. Cameron.
The condition of certain matrices. L. F. Shampine.
Some number-theoretic calculations. K. E. Kloss.

Radio Sci. J. Res. NBS/URSI **69D**, *No. 12 (Dec. 1965)*

Symposium on Planetary Atmospheres and Surfaces, May 1965:
I Session: Jupiter, as observed at long radio waves.
II Session: Jupiter, as observed at short radio waves.
III Session: Passive radio observations of Venus, Saturn, Mercury, Mars, and Uranus.
IV Session: Passive radio observations of the Moon.
V Session: Radar observations of the planets.
VI Session: Radar observations of the Moon.
Index to volume 69D, January to December 1965.

Other NBS Publications

Oxidation of polycyclic, aromatic hydrocarbons. A review of the literature, R. S. Tipson, NBS Mono. 87 (Sept. 17, 1965), 40 cents.
Spot diagrams for the prediction of lens performance from design data, O. N. Stavroudis and L. E. Sutton, NBS Mono. 93 (Sept. 7, 1965), 75 cents.
Specifications, tolerances, and other technical requirements for commercial weighing and measuring devices, NBS Handb. 44–3rd Edition (Oct. 12, 1965), $2.00. Supersedes NBS Handb. 44–2nd Edition.
Standard Reference Materials: Catalog and price list of standard materials issued by the National Bureau of Standards, NBS Misc. Publ. 260 (Oct. 1, 1965), 45 cents. Supersedes NBS Misc. Publ. 241.
The normal phase variations of the 18 kc/s signals from NBA observed at College, Alaska, J. H. Crary and A. C. Murphy, NBS Tech. Note 206–4 (Sept. 30, 1965), 25 cents.
The normal phase variations of the 16 kc/s signals from GBR observed at College, Alaska, J. H. Crary and A. C. Murphy, NBS Tech. Note 206–5 (Sept. 30, 1965), 30 cents.
HAYSTAQ. A mechanized system for searching chemical information, E. C. Marden, NBS Tech. Note 264 (Sept. 27, 1965), 50 cents.
Tabulation of published data on soviet electron devices through June 1965, C. P. Marsden, NBS Tech. Note 265 (Oct. 1, 1965), 50 cents. Supersedes NBS Tech. Note 186.
Selected values of chemical thermodynamic properties. Part 1. Tables for the first twenty-three elements in the standard order of arrangement, D. D. Wagman, W. H. Evans, I. Halow, V. B. Parker, S. M. Bailey, and R. H. Schumm, NBS Tech. Note 270–1 (Oct 1, 1965), 65 cents. Supersedes NBS Circ. 500.
Spectrochemical analysis: Optical spectrometry, x-ray fluorescence spectrometry, and electron probe microanalysis techniques July 1964 to June 1965, Ed. B. F. Scribner, NBS Tech. Note 272 (Oct 21, 1965), 50 cents.
Boiling heat transfer for oxygen, nitrogen, hydrogen, and helium, E. G. Brentari, P. J. Giarratano, and R. V. Smith, NBS Tech. Note 317 (Sept. 20, 1965), 60 cents.
Numerical values of the path integrals for low and very low frequencies, L. A. Berry and M. E. Chrisman, NBS Tech. Note 319 (Sept. 2, 1965), 55 cents.
Spark planning damage in copper, J. J. Gniewek, A. F. Clark, and J. C. Moulder, NBS Tech. Note 321 (Sept. 6, 1965), 15 cents.
Surface tensions of normal and parahydrogen, R. J. Corruccini, NBS Tech. Note 322 (August 11, 1965), 20 cents.
Refractive index and dispersion of liquid hydrogen, R. J. Corruccini, NBS Tech. Note 323 (Sept. 24, 1965), 25 cents.
Interference predictions for the instrument landing system, G. D. Gierhart and M. E. Johnson, NBS Tech. Note 324 (Sept. 1965), 30 cents.

Publications in Other Journals

This column lists all publications by the NBS staff, as soon after issuance as practical. For completeness, earlier references not previously reported may be included from time to time.

Chemistry

Buffer solutions of tris (hydroxymethyl) aminomethane for *p*H control in 50 weight per cent methanol from 10° to 40° C, M. Woodhead, M. Paabo, R. A. Robinson, and R. G. Bates, Anal. Chem. **37**, 1291 (1965).
Electrode potentials in fused systems. IX. Liquid junction potentials in the AgCl-AgBr system, K. H. Stern, J. Electrochem. Soc. **112**, No. 10, 1049–1050 (Oct. 1965).
Isotopic mixing in nitrogen chemisorbed on W, J. T. Yates, Jr., and T. E. Madey, J. Chem. Phys. **43**, No. 3, 1055–1059 (Aug. 1, 1965).
Matrix isolation study of the reaction of Cl atoms with CO. The infrared spectrum of the free radical ClCO, M. E. Jacox and D. E. Milligan, J. Chem. Phys. **43**, No. 3, 866–870 (Aug. 1, 1965).
Random-walk model of chain-polymer adsorption at a surface, R. J. Rubin, J. Chem. Phys. **43**, No. 7, 2392–2407 (Oct. 1, 1965).
Some electrochemical aspects of germanium dissolution. Valence states and electrode potential, W. E. Reid, Jr., Phys. Chem. **69**, No. 9, 3168–3171 (Sept. 1965).
Theoretical electromotive forces for cells containing a single solid or molten oxide, W. J. Hamer, J. Electroanal. Chem. **10**, 140–150 (1965).

Engineering and Instrumentation

A pulsed refrigeration system for cryogenic magnet application, T. R. Strobridge and D. B. Mann (Proc. 1964 Cryo-

genic Engineering Conf., Univ. Pennsylvania, Phila., Pa., Aug. 18–24, 1964), Book, Advances in Cryogenic Engineering 10, Paper N–3, 54–61 (Plenum Press Inc., New York, N.Y., 1965).

An anomalous decrease of the elastic moduli at very low temperatures in some 300 series stainless steels, R. P. Reed and R. P. Miksell (Proc. 1964 Cryogenic Engineering Conf., Univ. Pennsylvania, Phil., Pa., Aug. 18–24, 1964), Book, Advances in Cryogenic Engineering 10, Paper A–5, 46–49 (Plenum Press Inc., New York, N.Y., 1965).

Avoiding errors from stray radiation in measuring the spectral emittance of diffusely reflecting specimens, H. E. Clark, Appl. Opt. Letter to Editor **4,** No. 10, 1356–1357 (Oct. 1965).

Calibration of Bell-type provers by bottling and strapping, C. T. Collett (Proc. 24th Annual Appalachian Gas Measurement Short Course, 1964), West Virginia Univ. Tech. Bull. 73, 59–65 (1965).

Calibration of microphones, vibration pickups, and earphones, R. K. Cook, S. Edelman, and W. Koidan, J. Audio Engr. Soc. **13,** No. 4, 290–296 (Oct. 1965).

Considerations when using turbine-type flow-meters in cryogenic service, W. J. Alspach and T. M. Flynn (Proc. 1964 Cryogenic Engineering Conf., Univ. Pennsylvania, Phila., Pa., Aug. 18–24, 1964), Book, Advances in Cryogenic Engineering 10, Paper F–3, 246–252 (Plenum Press Inc., New York, N.Y., 1965).

Four methods of determining temperature sensitivity of strain gages at elevated temperatures, C. H. Melton and R. L. Bloss, ISA J. **12,** No. 10, 69–74 (Oct. 1965).

International comparison of dielectric measurements, H. E. Bussey, J. E. Gray, E. C. Bamberger, E. Rushton, G. Russell, B. W. Petley, and D. Morris, IEEE Trans. Instr. Meas. **IM–13,** No. 4, 305–311 (Dec. 1964).

Nucleate and film pool boiling design correlations for O_2, N_2 and He, E. G. Brentari and R. V. Smith (Proc. 1964 Cryogenic Engineering Conf., Univ. Pennsylvania, Phila., Pa., Aug. 18–24, 1964), Book, Advances in Cryogenic Engineering 10, Paper T–1, 325–341 (Plenum Press Inc., New York, N.Y., 1965).

Production of alumina windows, H. Johnson and R. D. Deslattes, Rev. Sci. Instr. **36,** No. 9, 1381–1382 (Sept. 1965).

Solid-vapor equilibrium in the system hydrogen-methane, M. J. Hiza and R. N. Herring (Proc. 1964 Cryogenic Engineering Conf., Univ. Pennsylvania, Phila., Pa., Aug. 18–24, 1964), Book, Advances in Cryogenic Engineering 10, Paper Q–5, 182–191 (Plenum Press Inc., New York, N.Y., 1965).

Transfer line surge, W. G. Steward (Proc. 1964 Cryogenic Engineering Conf., Univ. Pennsylvania, Phila., Pa., Aug. 18–24, 1964), Book, Advances in Cryogenic Engineering 10, Paper I–3, 313–322 (Plenum Press Inc., New York, N.Y., 1965).

Metrology

The international system of units, A. G. McNish, Mater. Res. Stds. **5,** No. 10, 528–532 (Oct. 1965).

Physics

DC dielectric conductance (reciprocal resistance) and conductivity (reciprocal resistivity) measurements, A. H. Scott, Book, Testing of Polymers 1, Ch. 6, 213–236 (Interscience Publ. Inc., New York, N.Y., 1965).

Dispersion characteristics of the 1.15μ He–Ne laser line, H. S. Boyne, M. M. Birky, and W. G. Schweitzer, Jr., Appl. Phys. Letters **7,** No. 3, 62–65 (Aug. 1, 1965).

Inelastic scattering of electrons by helium, G. E. Chamberlain and H. G. M. Heideman, Phys. Rev. Letters **15,** No. 8, 337–338 (Aug. 1965).

Infrared measurements on allene and allene-d_4, A. G. Maki and R. A. Toth, J. Mol. Spectr. **17,** No. 1, 136–155 (July 1, 1965).

Interaction between configurations with several open shells, U. Fano, Phys. Rev. **140,** No. 1A, A67–A75 (Oct. 4, 1965).

Nuclear resonance spin-echo study of Eu^{153} in EuO, G. A. Uriano and R. L. Streever, Physics Letters **17,** No. 3, 205–206 (July 15, 1965).

Nuclear resonance study of gallium-substituted yttrium iron garnet, R. L. Streever and G. A. Uriano, Phys. Rev. **139,** No. 1A, A305–A313 (July 5, 1965).

Nuclear resonance study of hyperfine fields in nickel-rich nickel-cobalt alloys, R. L. Streever and G. A. Uriano, Phys. Rev. **139,** No. 1A, A135–A141 (July 5, 1965).

Results of an absolute determination of the acceleration of gravity, J. E. Faller, J. Geophys. Res. **70,** No. 16, 4035–4038 (Aug. 15, 1965).

Book, Some aspects of non-equilibrium thermodynamics in the presence of a radiation field, R. N. Thomas (University of Colorado Press, Boulder, Colo., 1965).

Thermal conductivity and thermoelectric power of rutile (TiO_2), W. R. Thurber and A. J. H. Mante, Phys. Rev. **139,** No. 5A, A1655–A1665 (Aug. 30, 1965).

Nature of the electromagnetic field reflector from a coastline, J. R. Wait, Electronics Letters **1,** 65 (May 1965).

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Patents Granted on NBS Inventions

The following U.S. Patents have recently been granted on NBS inventions and, except as noted, are assigned to the United States of America as represented by the Secretary of Commerce.

3,194,783	July 13, 1965.	Silica-resin direct filling material and method of preparation. Rafael L. Bowen.
3,194,784	July 13, 1965.	Silica-resin direct filling material and method of preparation. Rafael L. Bowen.
3,200,142	August 10, 1965.	Surface-active comonomer and method of preparation. Rafael L. Bowen (Health, Education, and Welfare).
3,202,042	August 24, 1965.	System for measuring separately background and average line luminance or density. Ballard Jamieson and Robert Kee.
3,200,635	August 17, 1965.	Apparatus for determining melting points. Clyde L. McDaniel.
3,202,951	August 24, 1965.	Alloys and electrical transducers. Albert Krinsky (U.S. Atomic Energy Commission).
3,204,418	September 7, 1965.	Multivibrator-type control circuit for thermoelectric elements. Donald A. Mathews.
3,207,533	September 21, 1965.	Double bayonet insulated transfer line coupling. Donald A. Van Gundy, Robert J. Richards, Willis G. Steward, and Robert B. Jacobs (Air Force).

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